Space Weather Technical Forecast

Issued on Monday, 14 March 2022 at 01:18 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: CME arrived on the 13th, with G1/Minor geomagnetic storms expected early on Day 1 (14th) with a chance of G2/Moderate storm. Reduce risk of further M-Class flares.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Low over the past 24 hours, with only minor C-class flares observed. Peak flare was a C5 from the plage area in the northwest, near ex-AR2962. There are currently four numbered sunspot regions on the visible disc. The largest of these AR2965 Fai/Beta has shown some slight development in its intermediate spots, but remains relatively stable. AR2960 Hhx/alpha will be rotating off the Earth-side of the disc in the next 12 hours or so. Meanwhile, AR2967 and AR2968 are both simple regions. There is a new and un-numbered sunspot emerging in the southern hemisphere, which is a small and simple Bxo/alpha configuration. AR2964 in the southwest has now rotated off the disc. There have been no Earth-directed CMEs in the last 24 hours.

Solar Wind / Geomagnetic Activity: Background solar wind speeds, observed by DSCOVR and ACE at L1, became elevated with the arrival of a CME at 13/1014 UTC. with solar winds reaching a peak of 586km/s at 13/1047 UTC, before declining to slightly elevated levels, currently near 460km/s. Solar wind density increased from below average levels to above average, peaking at 43ppcc at 13/1344 UTC. This was accompanied by the weak magnetic field (Bt) becoming strong, with a peak of 25nT at 13/1708 UTC. The all important north-south component (Bz) was initially positive (northward), but soon rotated to negative (southward) reaching a peak of -24nT at 13/2157 UTC. Phi angle was initially negative (towards the Sun) but rotated briefly to positive with the CME arrival, with slight fluctuations in the orientation thereafter.

Geomagnetic activity was Quiet (Kp 0-2) initially, before increasing to Active (Kp 4) 13/0900-1200 UTC following a sudden impulse at L1, with geomagnetic activity reaching G1/Minor Storm (Kp 5) between 13/1200-2100 UTC, with a G2/Moderate Storm (Kp 6) observed at 13/1200-1500 UTC and 13/2100-0000 UTC.

Energetic Particles / Solar Radiation: The high energy proton flux (greater than 10MeV) measured at GOES 16 was at background levels throughout. The high energy electron flux (greater than 2 MeV) was at background levels, with the corresponding 24-hour integrated electron fluence below the Active (1e8 integrated pfu) threshold. Observed fluence at 14/0000 UTC was 4.59e6 integrated pfu.

Four-Day Space Weather Forecast Summary

Solar Activity: Solar activity is expected to be mainly Low, perhaps Moderate, with a chance of M-class flares. The risk of M-flares mainly comes from AR2965 through Day 1 (14th), with the risk slightly reduced now AR2965 has rotated off the disc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Met Office Space Weather Technical Forecast

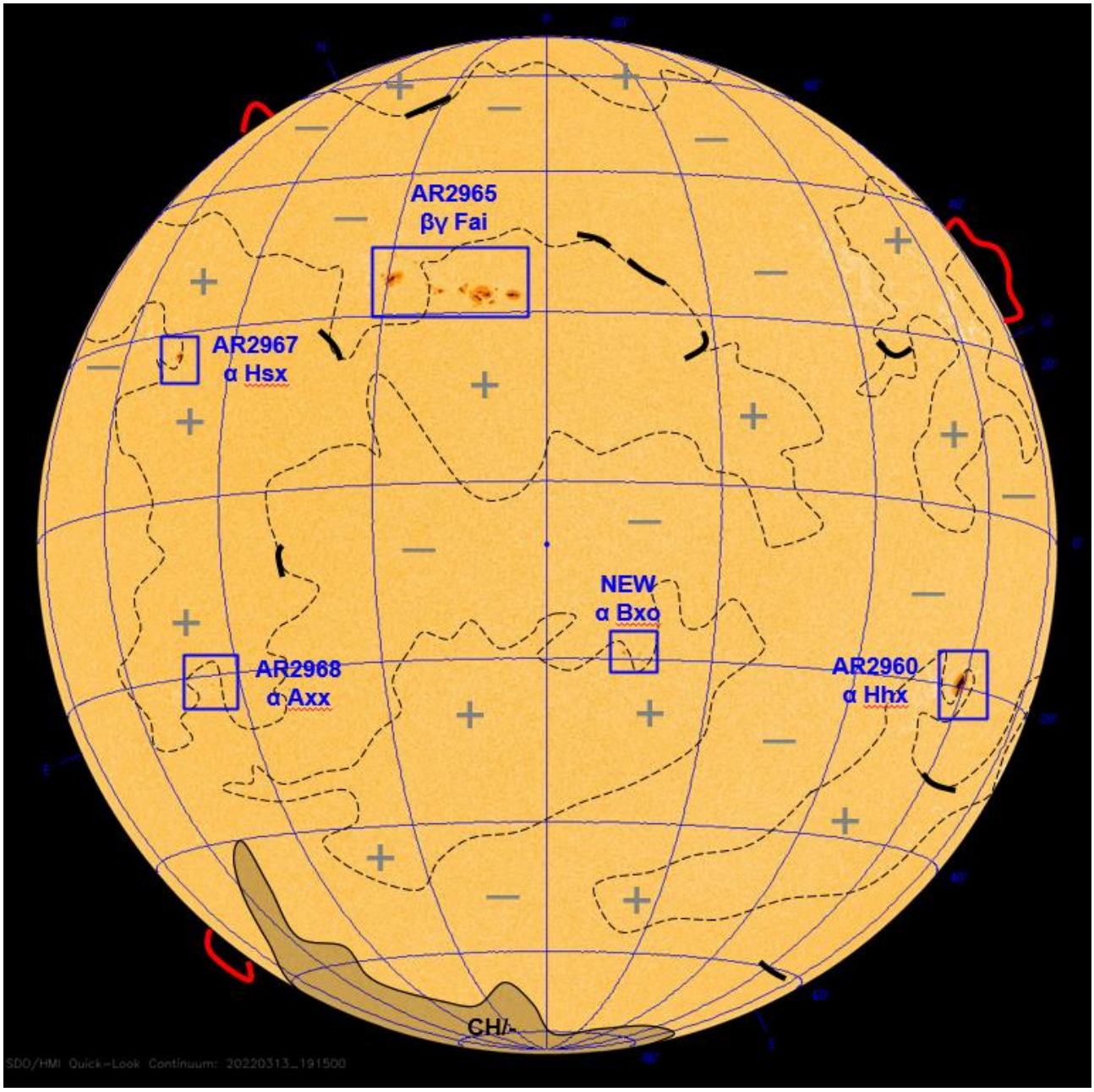
Solar Wind / Geomagnetic Activity: Ongoing CME effects are expected early day 1 (14th), with G1/Minor Geomagnetic Storms expected and a chance of G2/Moderate geomagnetic storms. Once Earth exits the trailing portion of the CME day 1 (14th), solar winds are expected to gradually ease to background levels, with no further enhancements expected. Geomagnetic activity will then gradually return to largely Quiet conditions with isolated Unsettled intervals Days 2-4 (15-17th).

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux is expected to remain predominantly at background levels. The high energy (greater than 2 MeV) electron flux is currently at background levels. An increase in electron flux is likely as CME effects wane through Days 2-4 (15-17th), perhaps reaching High levels at diurnal peak. The corresponding fluence is expected to be below the Active threshold (1e8 integrated pfu) through much of this period, with an increase possible through Days 2-4 (15-17th).

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Figure 1. Solar Analysis Valid 13/1915UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Geomagnetic Storms:

A CME arrival recently occurred, with impact at L1 at 13/1014 UTC. This was likely the arrival of the large Halo CME from the long duration C-class flare from ex-AR2962 on the 10th, but perhaps incorporates some element from a filament eruption on the 9th March. Solar winds are currently slightly elevated, at around 460km/s, with the CME effects continuing early on day 1 (14th) as the magnetic flux rope potentially brings further periods of negative (southward) orientation. However, once the CME completes its passing during day 1 (14th), solar winds are expected to only gradually ease towards background through the rest of the period. Geomagnetic activity is currently at G1/G2 Minor-Moderate storming as the CME and magnetic flux rope continues to pass Earth early on day 1 (14th). Activity gradually easing through the 14th becoming mostly Quiet with isolated unsettled spells by days 2-4 (15-16th).

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	70	20	1	1
Strong	G3	No	2	1	1	1
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
11/0406	Halo	C5-flare and filament	11W 23N	577	13/2200UTC	Arrived 13/1014 UTC. Could have included above CME

Figure 2: BGS Planetary K Index (Kp) shows G1/G2 Minor-Moderate (Major) Storms (Kp5-6).

Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

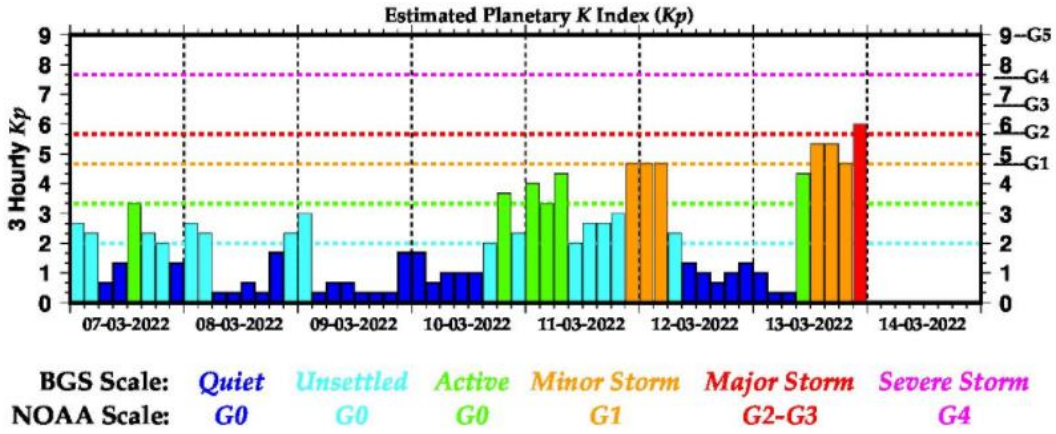
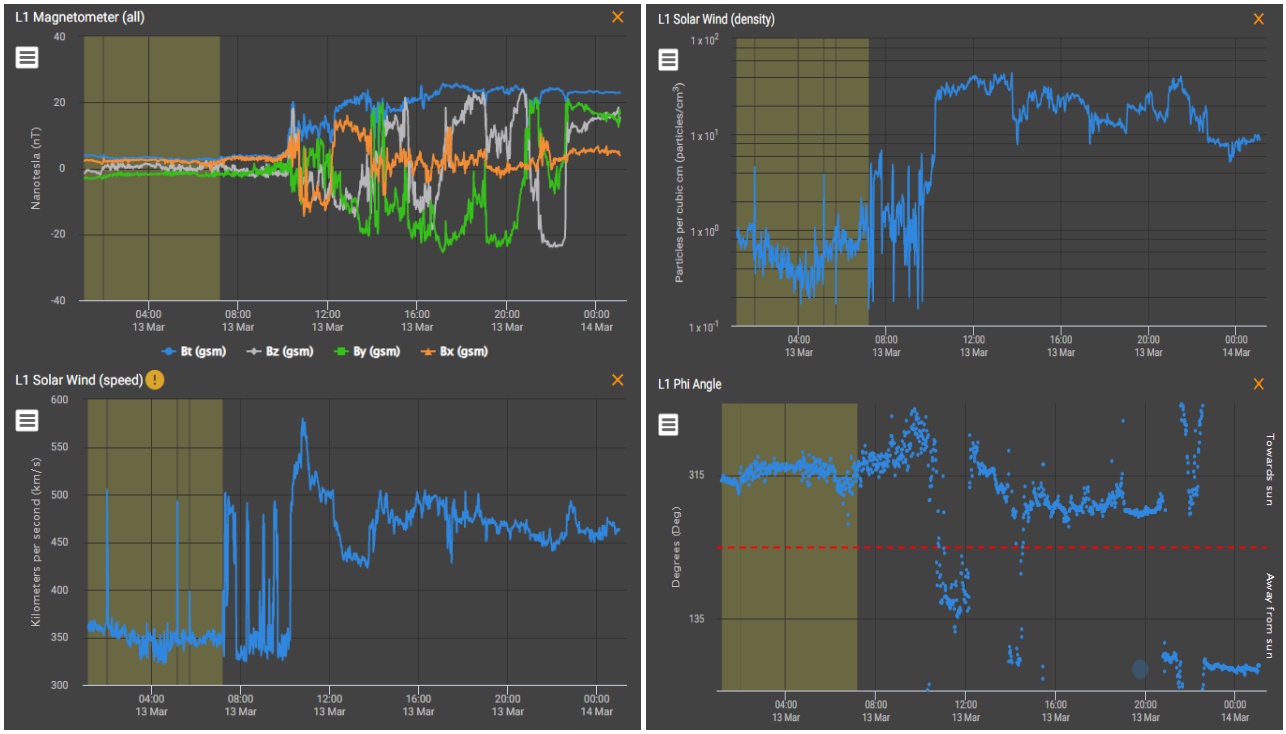


Figure 3: L1 Observed Solar wind parameters, during the CME arrival and event.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

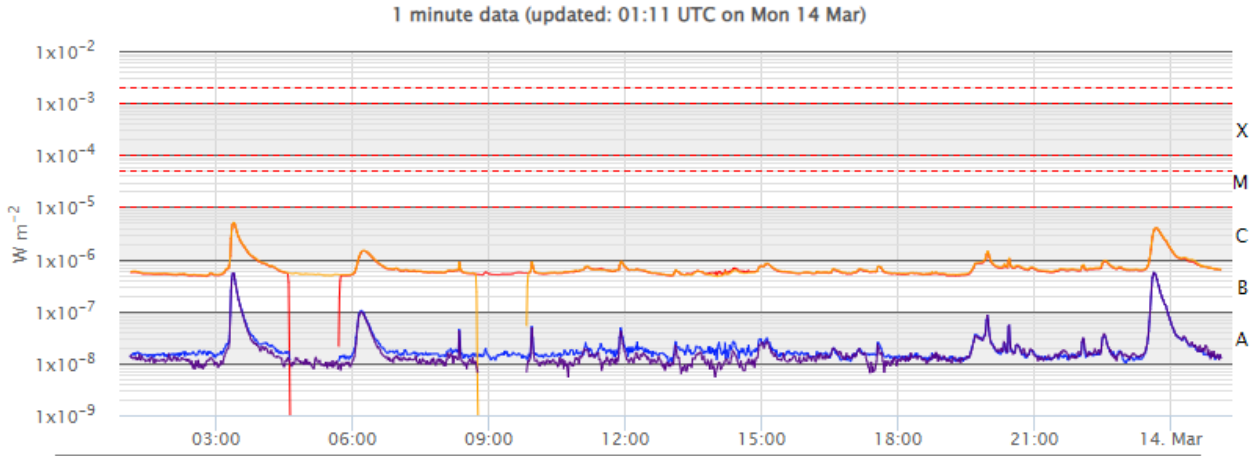
Radio Blackouts - X-Ray Flares:

There are currently four numbered sunspot regions on the visible disc, with Low solar activity. The largest flare, a C5 at 13/0323UTC originated from the plage region in the northwest, near to the location of ex-AR2962. The largest and most prominent region is AR2965, Fai/Beta-gamma in the northeast which has continued to show development of immature penumbra amongst its intermediate spots, but activity remains fairly muted. Likewise, AR2960, the large Cho/Beta spot in the southwest has remained stable, with no flare activity observed. 2964 Dso/Beta has rotated off the disc, and was the source of an M2-flare on the 12th. AR2968 Axx/alpha in the southeast is a small unipolar spot, but was the source of C1-flare 13/0615 UTC, although no further development has since occurred. The final spot is a small Hsx/alpha region in the northeast. A new and currently un-numbered sunspot has emerged in the southern hemisphere, which is a small and simple Bxo/alpha configuration.

Activity is forecast to remain Low with further C-flares expected, and a chance of increasing to Moderate from any M-flares, with the main risk from AR2965, and potentially AR2960 as it rotates off the limb.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	No	20	15	10	10
Very Active	R3 to R5 X Class	No	2	2	1	1

Figure 4: GOES-16 X-Ray Flares.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.

Solar Radiation Storms - (High Energy Protons):

The high energy proton flux (10MeV) measured at GOES 16 has returned to background levels after a slight rise due to the long period C-class flare from a plage region in the northwest on 10 March. There is just a very slight chance of an S1/Minor radiation storm, should any further flares occur from this plage region, or from any of the larger regions on the disc.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	2	2	2	2
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

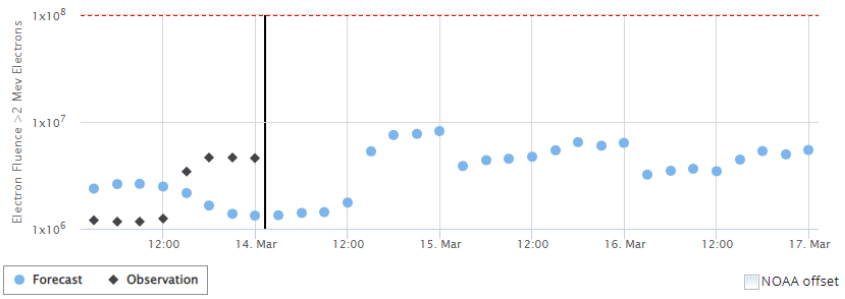
High Energy Electrons Event (≥ 2MeV):

The high energy (greater than 2 MeV) electron flux as observed at GEO by GOES-16, is currently at background levels. Recent CME arrival has the potential to elevate electron numbers, with the potential for moderate to high flux developing day 1 (14th), once any geomagnetic activity subsides. Elevated solar winds are then expected to gradually ease, with no other notable enhancements currently forecast.

The associated 24 hour electron fluence is expected to remain below the Active threshold, but with a slight chance of rising above day 2-4 (15-17th) as the geomagnetic effects wane following the passage of the CME from the 13th. REFM is giving good guidance at first, but will not take account of the recent CME arrival, with poor guidance likely from the 14th onward.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	20	25	30	30
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

Figure 5: Met Office REFM observations and forecast.



Issued by Met Office Space Weather Advisor, Tel: +44 (0) 330 135 4254 Email: moswoc@metoffice.gov.uk

© Crown Copyright 2022. All Rights Reserved.